

# N-BODY SIMULATIONS AND MOCK MAKING

Jeremy Tinker  
Berkeley Center for Cosmological Physics



# VISIT THE WIKI PAGE

<https://bigboss.lbl.gov/trac/wiki/CosmoSim>

- What are our simulation needs and goals?
- What do we have in hand?
- What methods can we combine with the simulations?

# WHAT DO WE NEED THE SIMULATIONS FOR?

- Covariance matrices
  - volume! volume! volume!
- Mock catalogs for survey selection
  - selection based on galaxy properties
  - fiber collisions/angular window function
- Mocks for testing other codes and statistics
  - finding groups of galaxies
  - estimating local galaxy densities

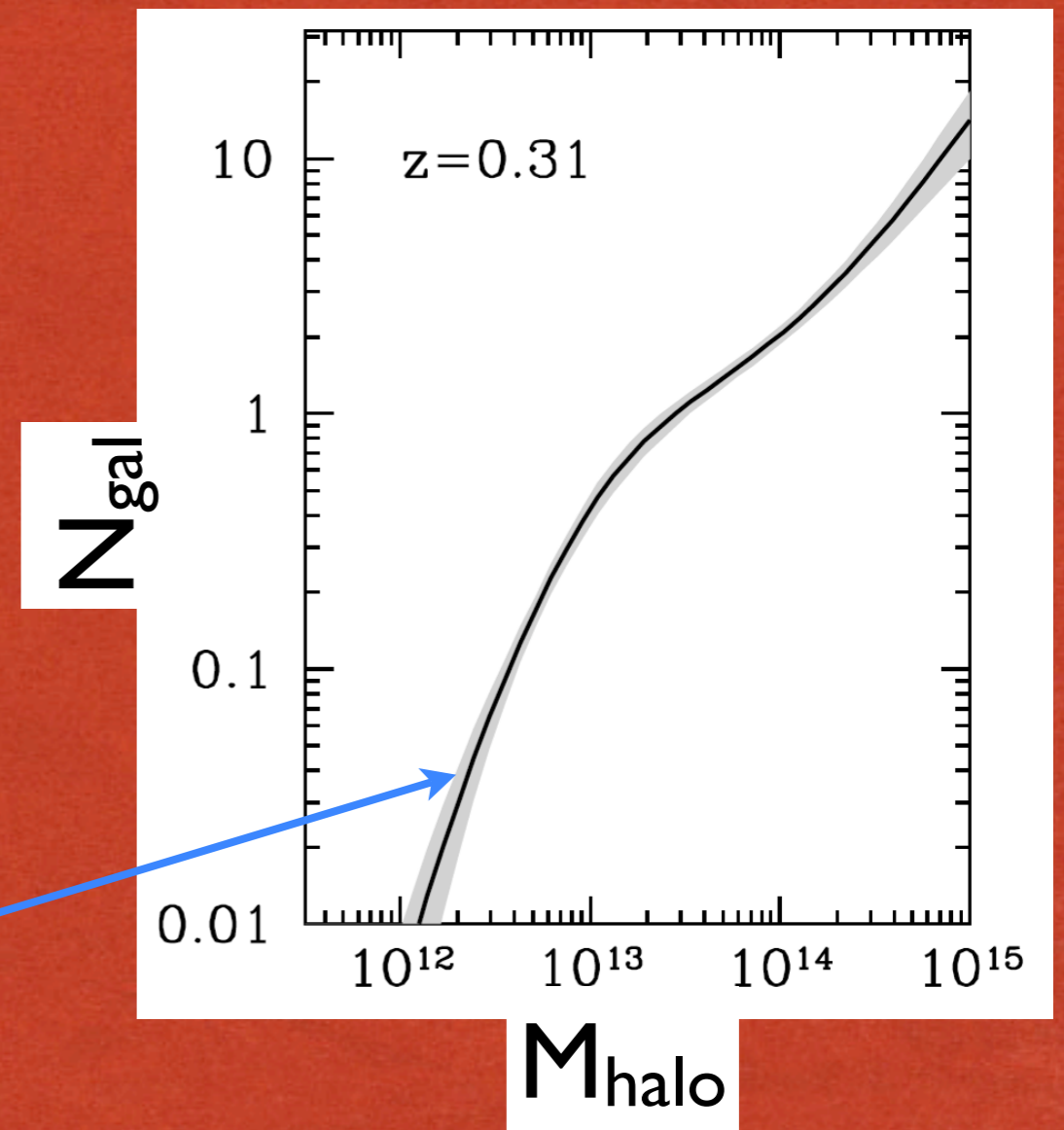
# WHAT ARE THE SIMULATION REQUIREMENTS?

- The big fight: Volume versus Mass Resolution.
- How do the requirements change with galaxy sample?
  - LRGs
  - Emission Line Galaxies (ELGs)
  - QSOs -  $\text{Ly}\alpha$  forest.



# LUMINOUS RED GALAXIES

- Best-known galaxy sample. Information from photo-LRGs and BOSS.
- Volume  $z=0.6-1.0$ ,  $14 \text{ (Gpc/h)}^3$  (north only).
- target  $n_{\text{gal}} \sim 3 \times 10^{-4} \text{ (Mpc/h)}^{-3}$ , halo mass scale  $\sim 10^{13} M_{\text{sol}}/\text{h}$ .
- BUT: mass-luminosity scatter determines resolution requirements.



*Padmanabhan et al 2009*

# LRGS: RESOLUTION REQUIREMENTS

$$\lambda = L_{\text{box}} / n_p^{1/3}$$

- Minimum mass scale for LRGS:  $10^{12} M_{\text{sol}}/h$ .
- 100 particle halos:  $\lambda=0.5$  (robust)
- 20 particle halos:  $\lambda=0.9$  (a little dicey)
- How should we find halos?
  - FOF halo finder,  $I=0.168$  but assign SO(200) mass. (should be unbiased at low-N limit?).
  - SO finder alone: requires  $N > 100$  particles/halo
  - For LRGS, breaking bridges is important.

# LRGS: SIMULATIONS IN HAND

- Las Damas mocks:
  - 40 sims @ 2.4 Gpc/h,  $\lambda=2.0$
  - 40 sims @ 1 Gpc/h,  $\lambda=0.9$
  - How public are the catalogs? (halos, DM?)
- (Eastern) Horizon Run:  $L_{\text{box}}=6.6$  Gpc/h,  $\lambda=1.6$
- Uros' simulation:  $L_{\text{box}}=3.2$  Gpc/h,  $\lambda=0.8$
- New simulations?



# EMISSION LINE GALAXIES

- assume redshift interval:  $0.7 < z < 2.0$ 
  - distance: 2.0 Gpc/h
  - volume:  $68 \text{ (Gpc/h)}^3$
- Star-forming objects probe lower mass halos, but the survey spans larger volume.



Google image of a typical low- $z$  star forming galaxy.

# ELGS: WHAT GALAXIES DO THEY PROBE?

- Results from DEEP2.
- Not a strong correlation between  $L_{\text{OII}}$  and stellar mass.
- At fixed  $M_{\text{gal}}$ , SFR increases monotonically with redshift.

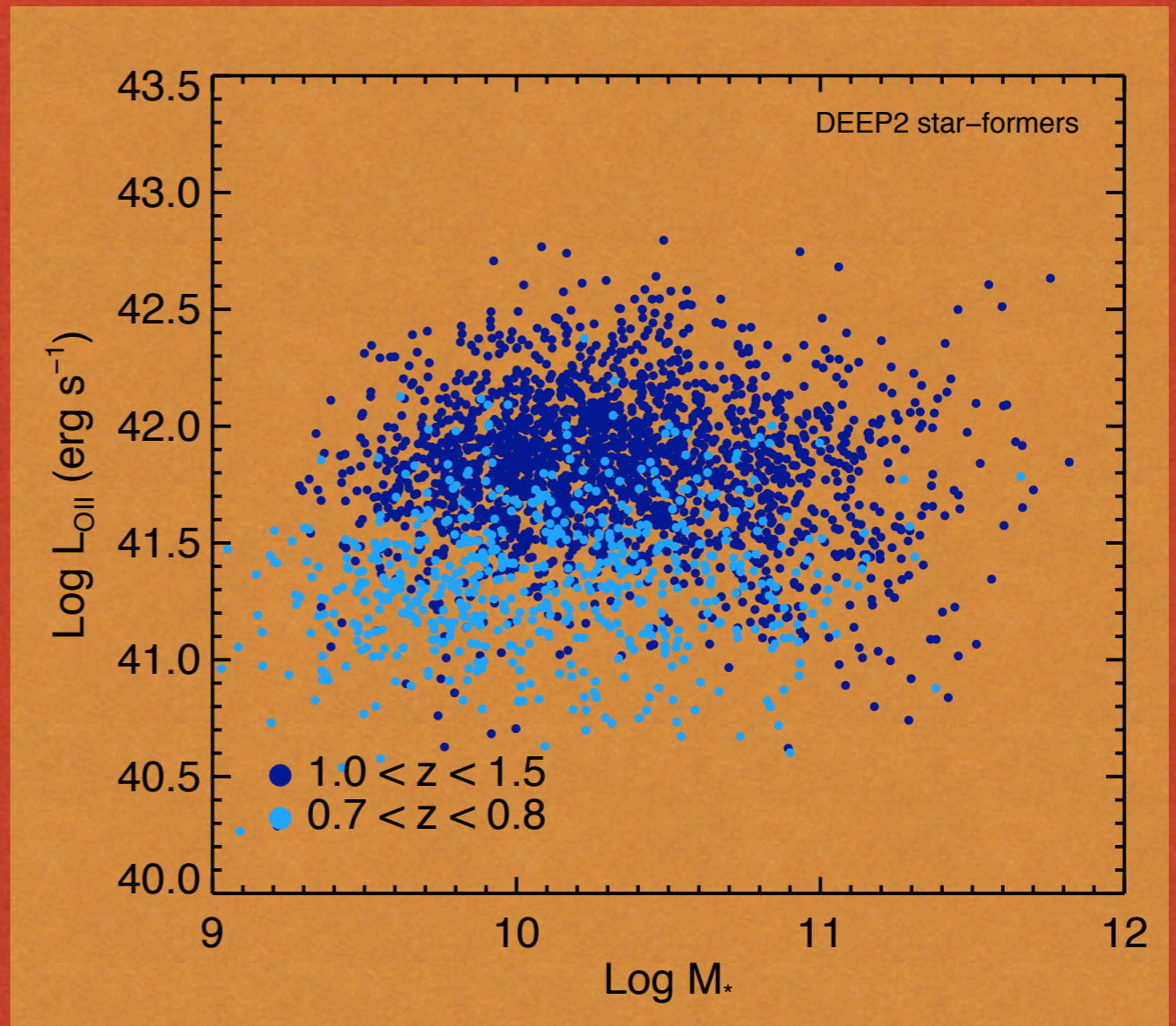
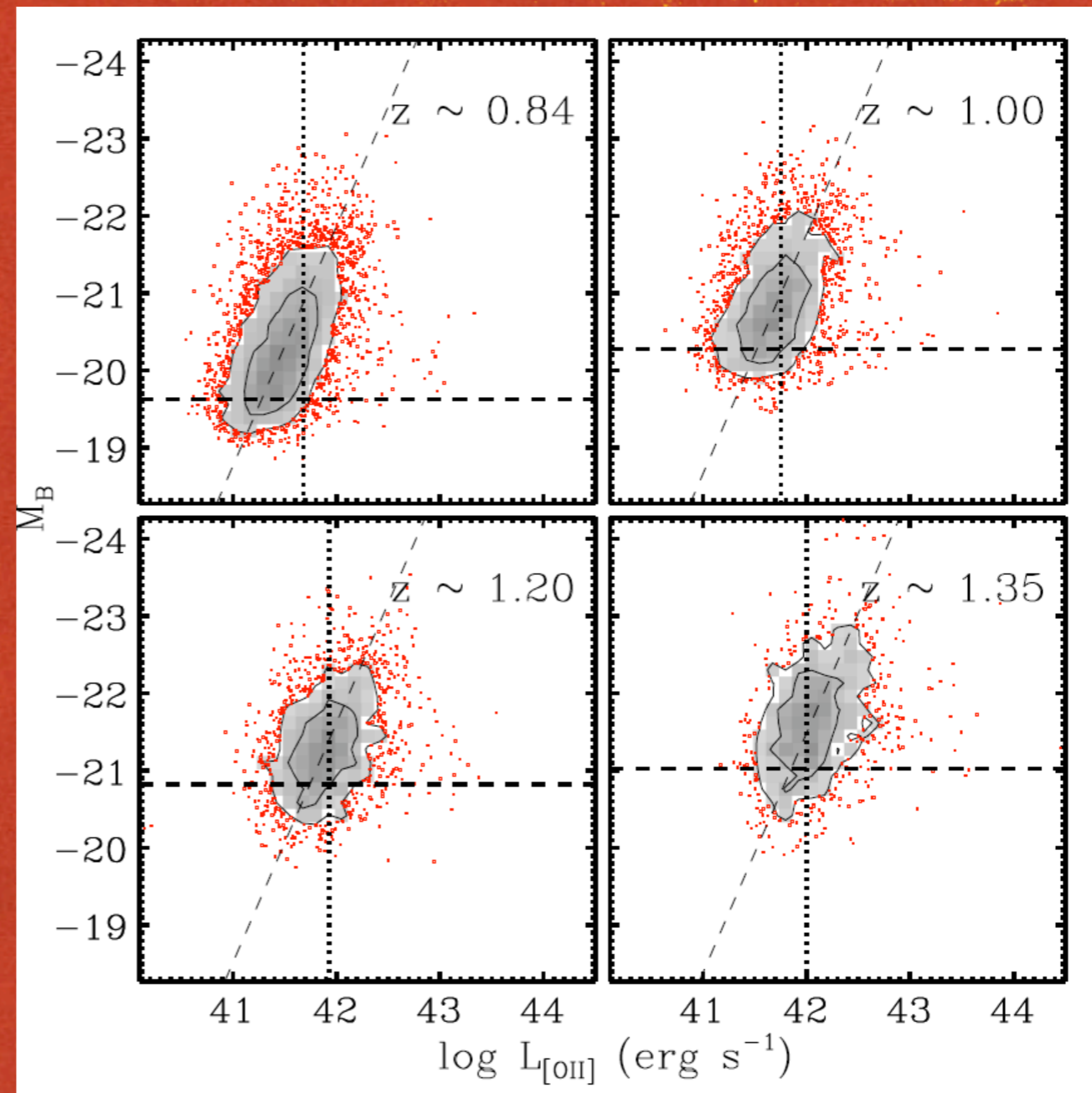


Figure made by Kevin Bundy

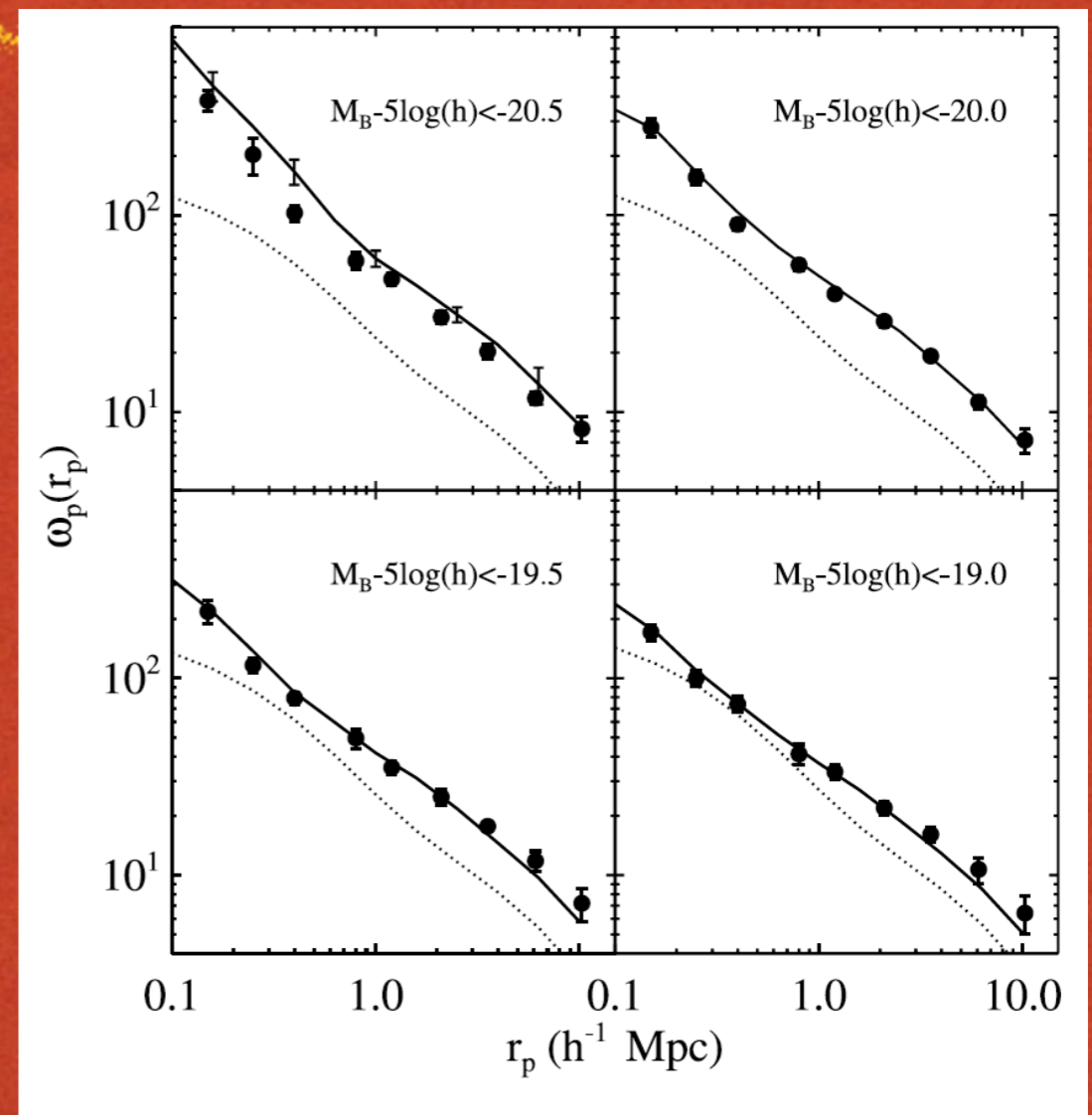
# ELGS: WHAT HALOS DO THEY PROBE?

- Zhu et al 2009  $L_{\text{OII}}$  luminosity function.
- Large scatter with B-magnitude.
- At  $L_{\text{OII}} > 42.6$ , sampling mostly this scatter.
- Aside: Why is there a correlation here but not with  $M_{\text{stellar}}$ ?



# ELGS: HALO MASSES I

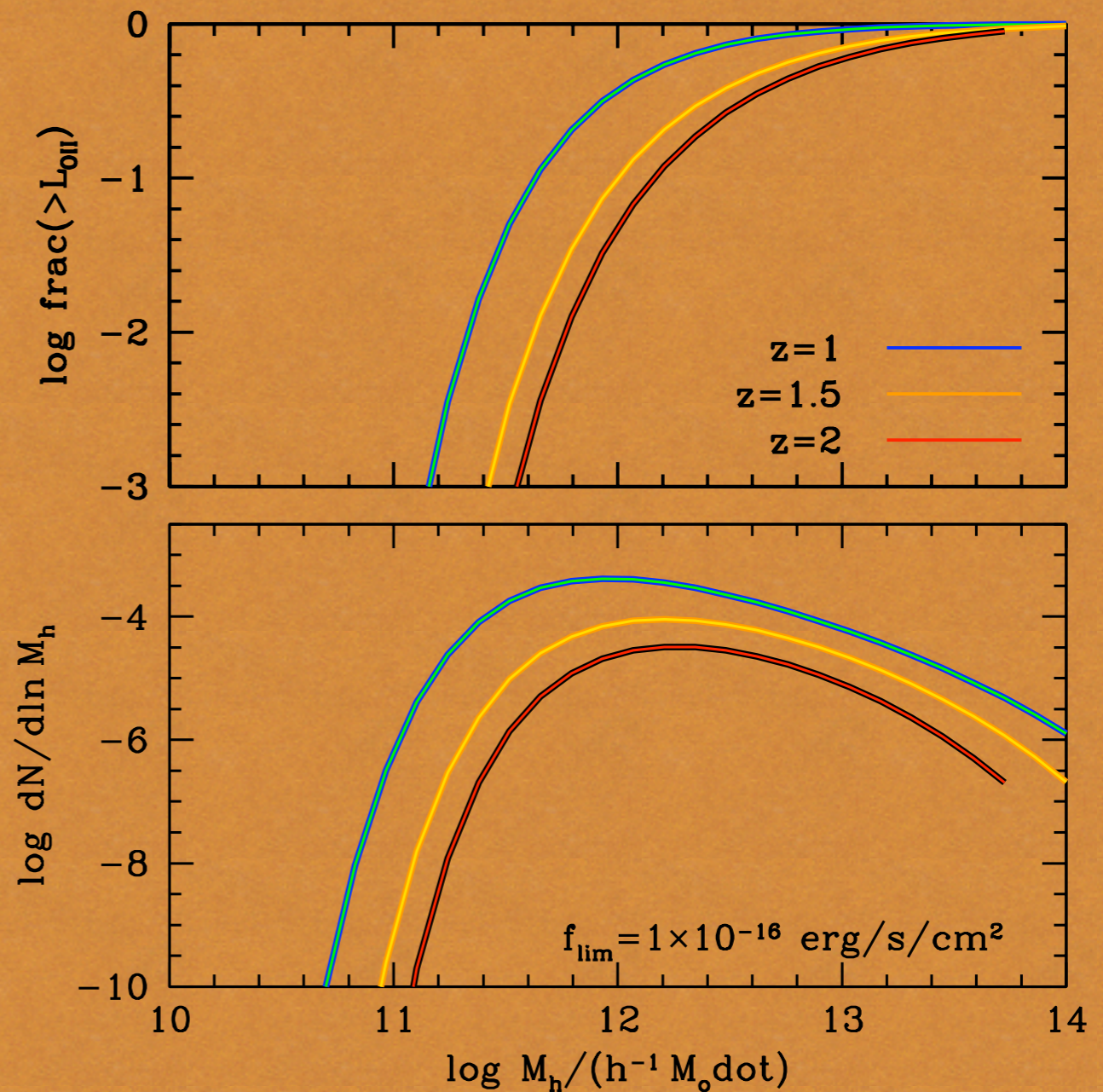
- Abundance matching method:
  - Map  $M_B$  onto  $M_{\text{halo}}$  assuming no scatter.
  - Get  $L_{\text{OII}}(M_B)$ , mean and scatter, from Zhu et al plot.
  - Determine what fraction of halos have  $L_{\text{OII}}$  above the detection threshold.



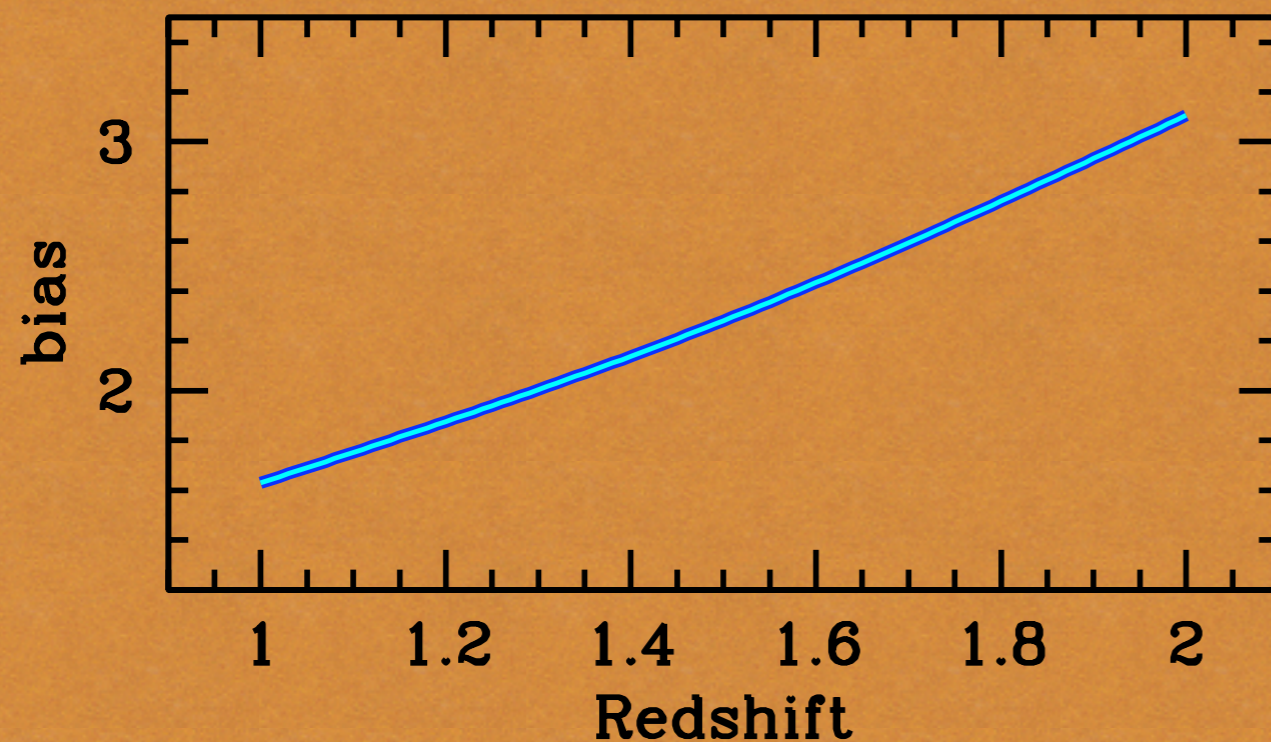
Conroy et al 2006:  
SHAM vs DEEP2 clustering

# ELGS: HALO MASSES I

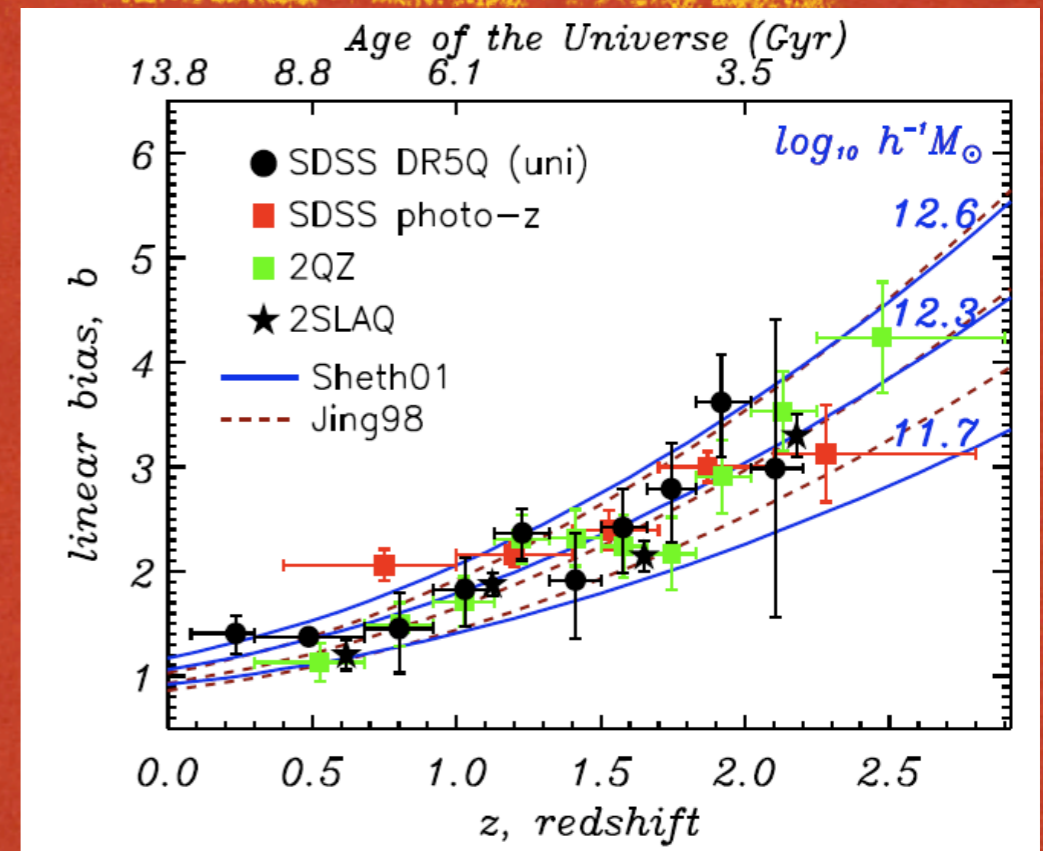
- Fraction of halos (and subhalos) with detectable  $L_{\text{OII}}$ .
- Halos  $M < 10^{12}$  are a substantial contribution.



# ELGS: HALO MASSES I



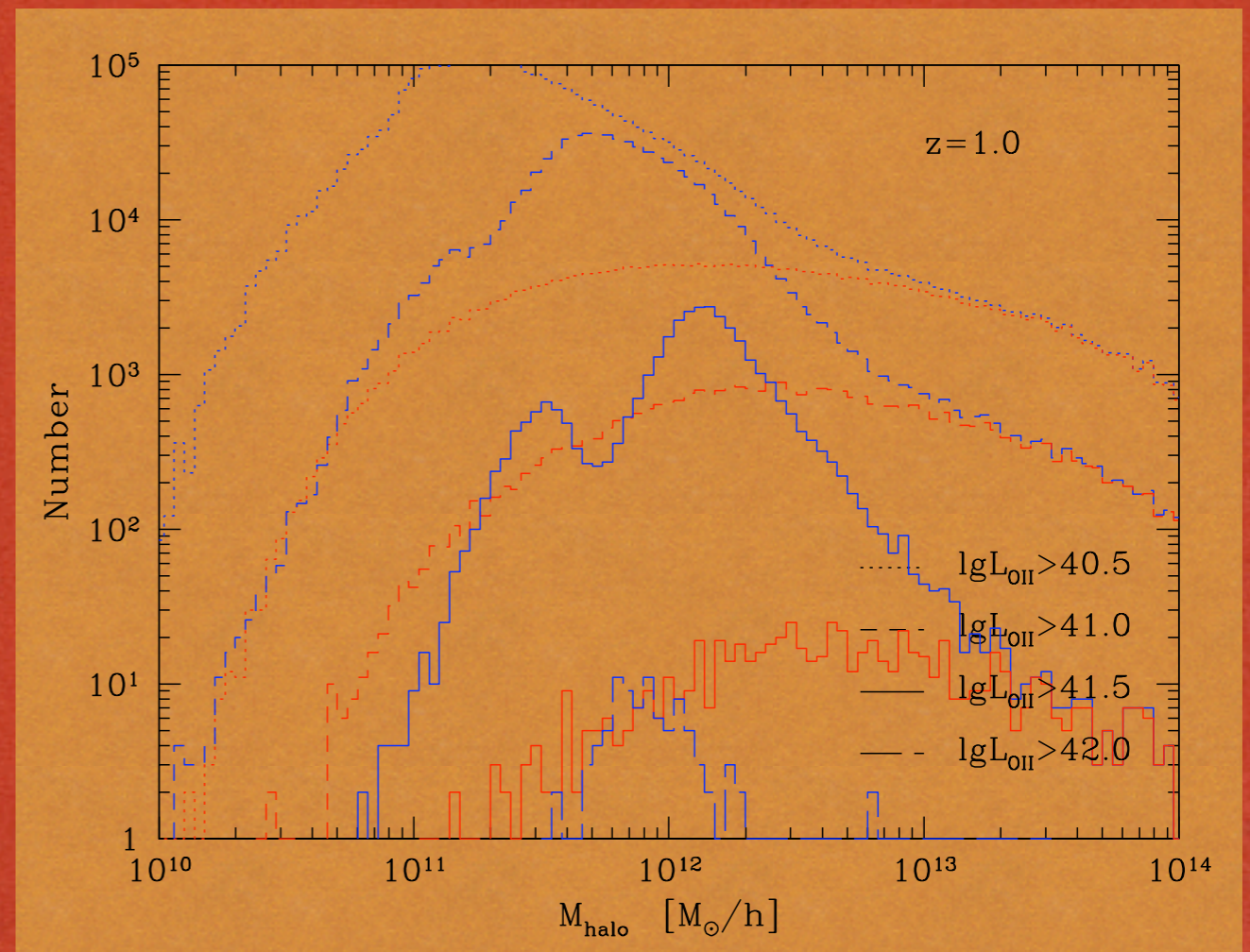
- Calculating the bias of those halo occupation functions.
- recall:  $M_{\text{star}} = 8E10$  to  $2E9$  @  $z=1-2$



Nic Ross's work  
on QSO clustering  
0903.3230

# ELGS: HALO MASSES II

- Martin has mined the Millennium SA database.
- Convert SFR to  $L_{\text{OII}}$ : Sumiyoshi et al 2009
- $M_{\text{min}} \sim 10^{11}$ ,  $\lambda=0.42$  (20 particles),  $\lambda=0.24$  (100 particles)
- For 1 Gpc/h box,  $n_p=2400^3$  ( $\lambda=0.42$ ).



# MAKING MOCKS

- Populate halos in a simulation using an HOD.
  - Well motivated/tested for LRGs.
  - Need clustering data in-hand.
  - Is the radial profile of satellite ELGs an NFW?
- Use a semi-analytic model for ELGs.
  - Box size an issue?
  - Use results from SA model to motivate the HOD.
- Hydrodynamic simulations?
  - Box size definitely an issue: bootstrap required.

# OPEN QUESTIONS

- How get a covariance matrices for our data?
- How will we achieve large volume for ELGs?
- What new simulations are required (and where will we get them)?
- Don't forget the wiki page! Put your mock/sim wish list there. List your simulations there.

<https://bigboss.lbl.gov/trac/wiki/CosmoSim>